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EVALUATION OF THE RELIABILITY IMPACT OF ENGINEERING CHANGE PROPOSALS

September 1976

Prepared for
NAVAL ORDNANCE STATION
Louisville, Kentucky 40214
under Contract N00197-74-C-0314
Task Assignment No. 9

ARINC RESEARCH CORPORATION

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This report presents the results of ARINC Research Corporation's efforts in to evaluate the reliability and availability impact of ECP 780-026 on the 5"/54 Mod 0 Gun Mount, using a computer simulation modeling technique.

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by

10 G. Mettler

ARINC Research Corporation
a Subsidiary of Aeronautical Radio, Inc.
2551 Riva Road
Annapolis, Maryland 21401

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ABSTRACT

This report presents the results of ARINC Research Corporation's efforts to evaluate the reliability and availability impact of ECP 780-026 on the 5"/54 Mark 45 Mod 0 Gun Mount, using a computer simulation modeling technique.

CONTENTS

CHAPTER ONE

INTRODUCTION

Under the terms of Specific Task Assignment No. 9 of Contract N00197-74-C-0314 with the Gun Systems Engineering Center (GSEC) at the Naval Ordnance Station, Louisville (NOSL), Kentucky, ARINC Research was tasked to evaluate the reliability impact of proposed changes to gun systems. One proposed change was forwarded for evaluation during the period of this task assignment: Engineering Change Proposal (ECP) 780-026, involving the recoil pistons on the 5"/54 Mk 45 Mod 0 Gun Mount. The recoil pistons were changed from E4340 steel to a chrome-plated design to reduce the high failure rate of the "U" cup hydraulic seals in the piston assembly. This report describes the analysis employed to assess the reliability impact of that change and identifies the improvements expected to result from the change.

CHAPTER TWO

PROCEDURE

We were asked to evaluate the effect of the proposed change (to chrome-plated recoil pistons) in the 5"/54 Mk 45 Mod 0 Gun Mount by using baseline Reliability, Maintainability, and Availability (RM&A) data established under Specific Task Assignment No. 7 of Contract N00197-76-C-0314. In that task we provided a baseline RM&A for the Mk 45 Gun Mount, using a computer simulation model. The details of the model and the baseline are presented in the Final Report for Specific Task Assignment No. 7*.

Information supplied by GSEC personnel indicated that an MRBF of 618 rounds for the recoil-piston assemblies had been established on the basis of firing 2115 rounds with an unmodified system. Following installation of the ECP, an MRBF of 1835 was measured after 1835 rounds were expended, with one failure occurring at 1402 rounds. The recoil pistons are contained within the gun barrel housing assembly. That assembly contains elements that could fail during both cycling and firing (rounds) operations. By the nature of gun operations, a mount will be cycled many more times than it is fired. A cycles-to-rounds ratio of 10:1 is reasonable.

A review of simulation-model parameters revealed that the recoil pistons were properly treated as part of the Gun Barrel Housing, model block 12a of the block diagram presented in the Appendix (block number 33 for computer simulation). The failure mode for this block was based on system cycles, and a predicted value of 5000 cycles had been assigned as the MCBF for the block. For use in the simulation model to project the improvement in the RM&A of the mount with the new chrome-plated pistons, the expected MCBF of block 12a was assumed to be 15,000 cycles -- three times the original value.

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*See ARINC Research Publication 1621-07-06-1523, September 1976.

CHAPTER THREE

FINDINGS

The new MCBF of 15,000 cycles was used to modify the input parameter for block 12a of the simulation model. Tables 1, 2, and 3 list the RM&A parameters for the modified system, as established by simulation of system operation for periods of varying lengths (after discounting of the first five years to allow the model outputs to stabilize). For purposes of comparisons, these tables also contain the RM&A parameters for the unmodified system values.

Table 1 gives the system parameters that were observed through 219,000 hours of simulated system operation under the four-year-cycle scenario. In this scenario, mount operational intervals varied between 0.2 and 8.0 hours, the average interval being four hours. Table 2 shows the results obtained by simulating system operation over 350,400 hours of the two-year-cycle scenario with the same operational-interval range and average. In Table 3 the data shown for the unmodified system represent 166,400 hours of simulated system operation, and the data for the unmodified system were observed over 50,000 hours of simulated system operation. These Table 3 data resulted from simulating system operation under continuous combat conditions where continuous operational intervals ranged from 0.2 to 21 hours in length and had a 11.5-hour average duration.

Each table gives the parameters MTBF, MT_EBF, MCBF, MRBF, Availability, and Reliability. These parameters are defined as:

$$\text{MTBF} = \frac{\text{Calendar Time (in Hours)}}{\text{Number of Failures}}$$

$$MT_EBF = \frac{\text{Energize Time (in Hours)}}{\text{Number of Failures while Energized}}$$

$$\text{MCBF} = \frac{\text{Number of Cycles}}{\text{Number of Failures while Cycling}}$$

$$\text{MRBF} = \frac{\text{Number of Rounds Fired}}{\text{Number of Failures while Firing}}$$

Table 1. 5"/54 MK 45 MOD 0 RM&A PARAMETERS, FOUR-YEAR SCENARIO		
Parameter	Unmodified System Mean	Modified System Mean
MTBF	629.3	590.3
MT_EBF	54.7	51.1
MCBF	67.1	67.5
MRBF	15.6	17.0
Availability	0.980	0.977
Reliability	0.931	0.927

Table 2. 5"/54 MK 45 MOD 0 RM&A PARAMETERS, TWO-YEAR SCENARIO		
Parameter	Unmodified System Mean	Modified System Mean
MTBF	518.3	534.1
MT_EBF	54.4	56.4
MCBF	70.4	69.6
MRBF	18.1	19.0
Availability	0.977	0.977
Reliability	0.931	0.933

Table 3. 5"/54 MK 45 MOD 0 RM&A PARAMETERS, COMBAT SCENARIO		
Parameters	Unmodified System Mean	Modified System Mean
MTBF	93.2	90.4
MT_EBF	72.0	70.3
MCBF	69.5	72.3
MRBF	13.9	13.8
Availability	0.857	0.861
Reliability	0.867	0.863

$$\text{Availability} = \frac{\text{(Hours of System Operation)} - \text{(Active Repair Hours)}}{\text{Hours of System Operation}}$$

$$\text{Reliability} = \frac{\text{(Number of Times Turned On)} - \text{(Number of Failures)}}{\text{Number of Times Turned On}}$$

As shown in Tables 1, 2, and 3, the modified-system mean values are close to the mean values of the unmodified system. The conclusion to be drawn from this analysis is that the Gun Barrel Housing Assembly has only a minor effect on total system reliability and availability. The 3-to-1 increase in the MCBF of block 12a has a negligible effect on system operation because the mission length in cycles (approximately 40 to 50 cycles) is relatively small compared with the mean values of 5,000 and 15,000 used for block 12a. The fact that the modified-system parameters increase in some cases and decrease in others is accounted for by the random variation of the simulation-modeling technique.

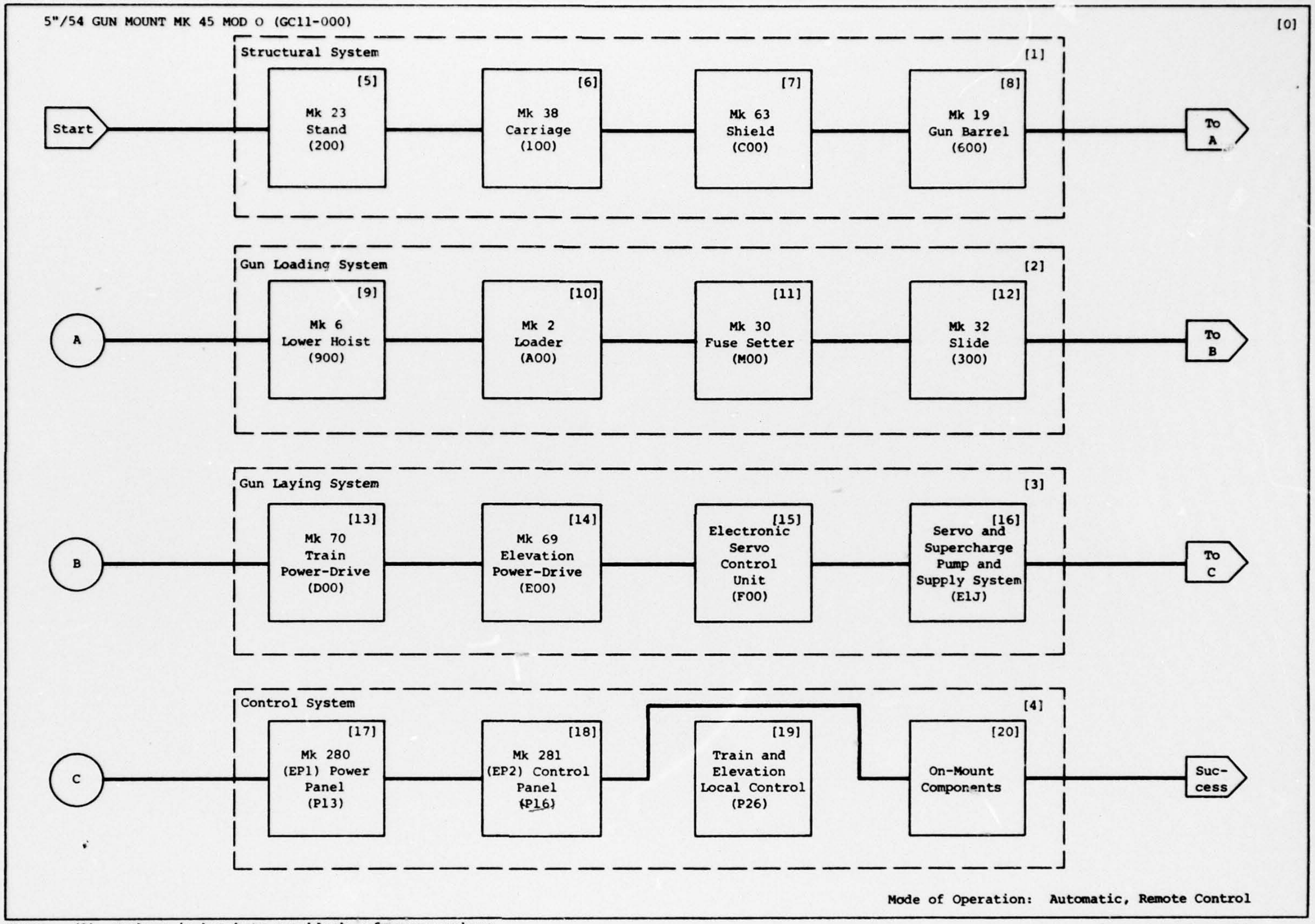
CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

The change to chrome-plated recoil piston rods should improve the reliability of the hydraulic seals, as demonstrated by the test results. However, the improvement to the overall gun system reliability from this change is minor. It is recommended that future proposed gun system improvements be evaluated for their effect on total gun system RM&A by using this simulation modeling technique.

APPENDIX

RELIABILITY BLOCK DIAGRAM
FOR THE 5"/54 MK 45 MOD 0 GUN MOUNT



Notes:
(1) Numbers in brackets are block reference numbers.
(2) Numbers in parentheses are Equipment Identification Code (EIC) numbers. The prefix, GC11-, applies to all EIC numbers.
(3) Block 19 is not used in the prescribed mode. It is included to enumerate all subsystems.
(4) Numbers in italics are simulation model reference numbers.

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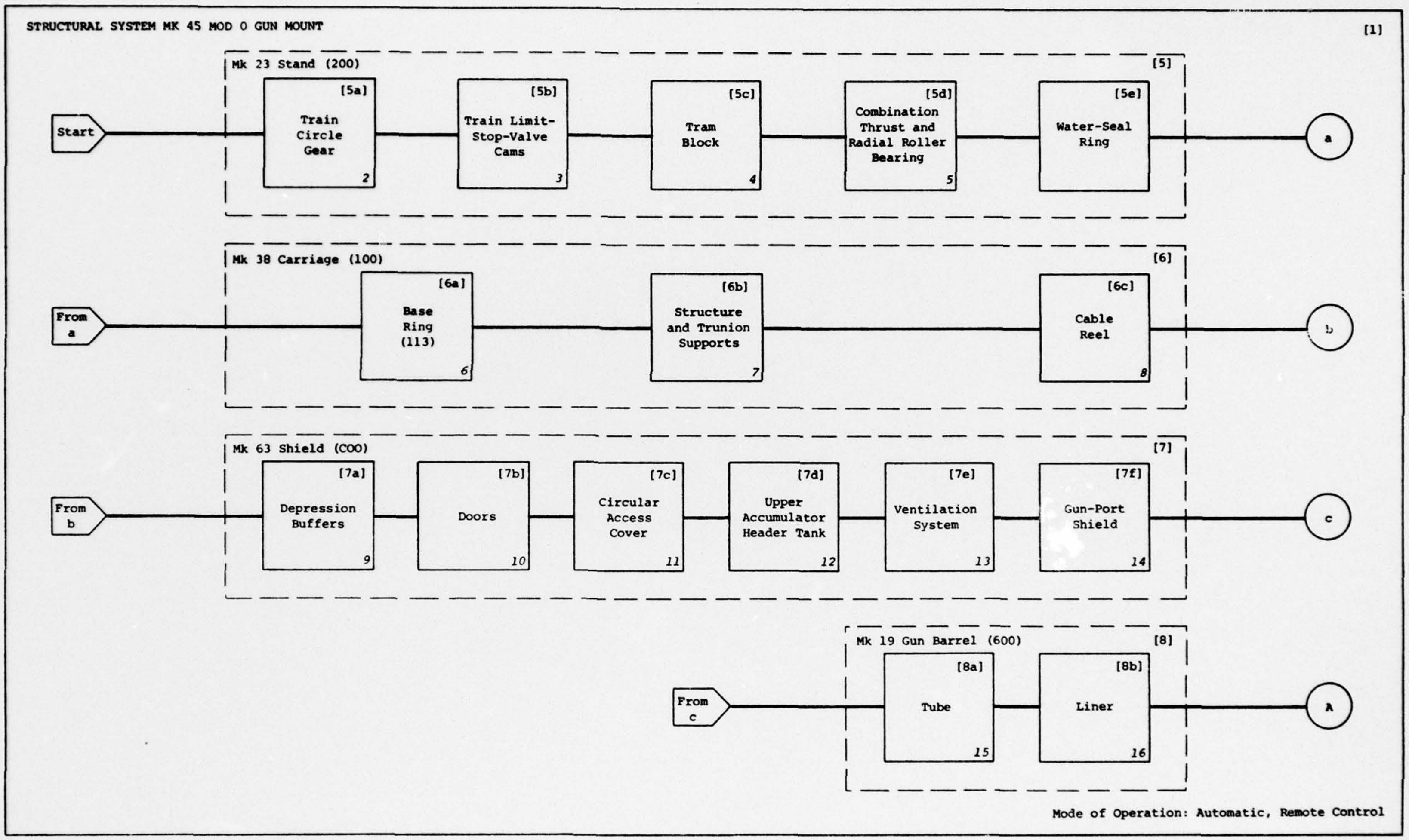
RELIABILITY BLOCK DIAGRAMS - 5-INCH 54 CALIBER LIGHT WEIGHT GUN MOUNT MK 45 MOD 0



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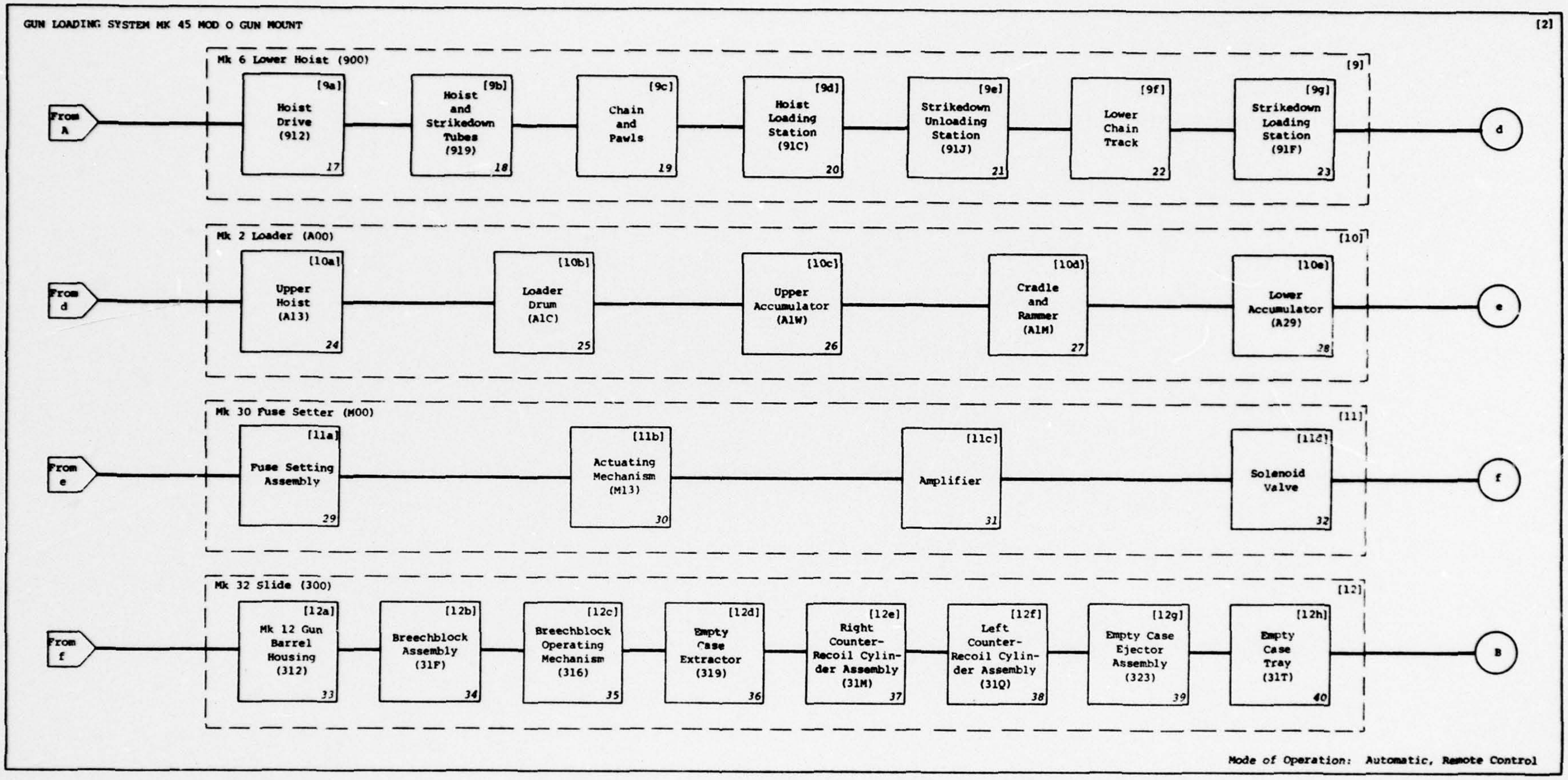
STRUCTURAL SYSTEM RELIABILITY BLOCK DIAGRAM



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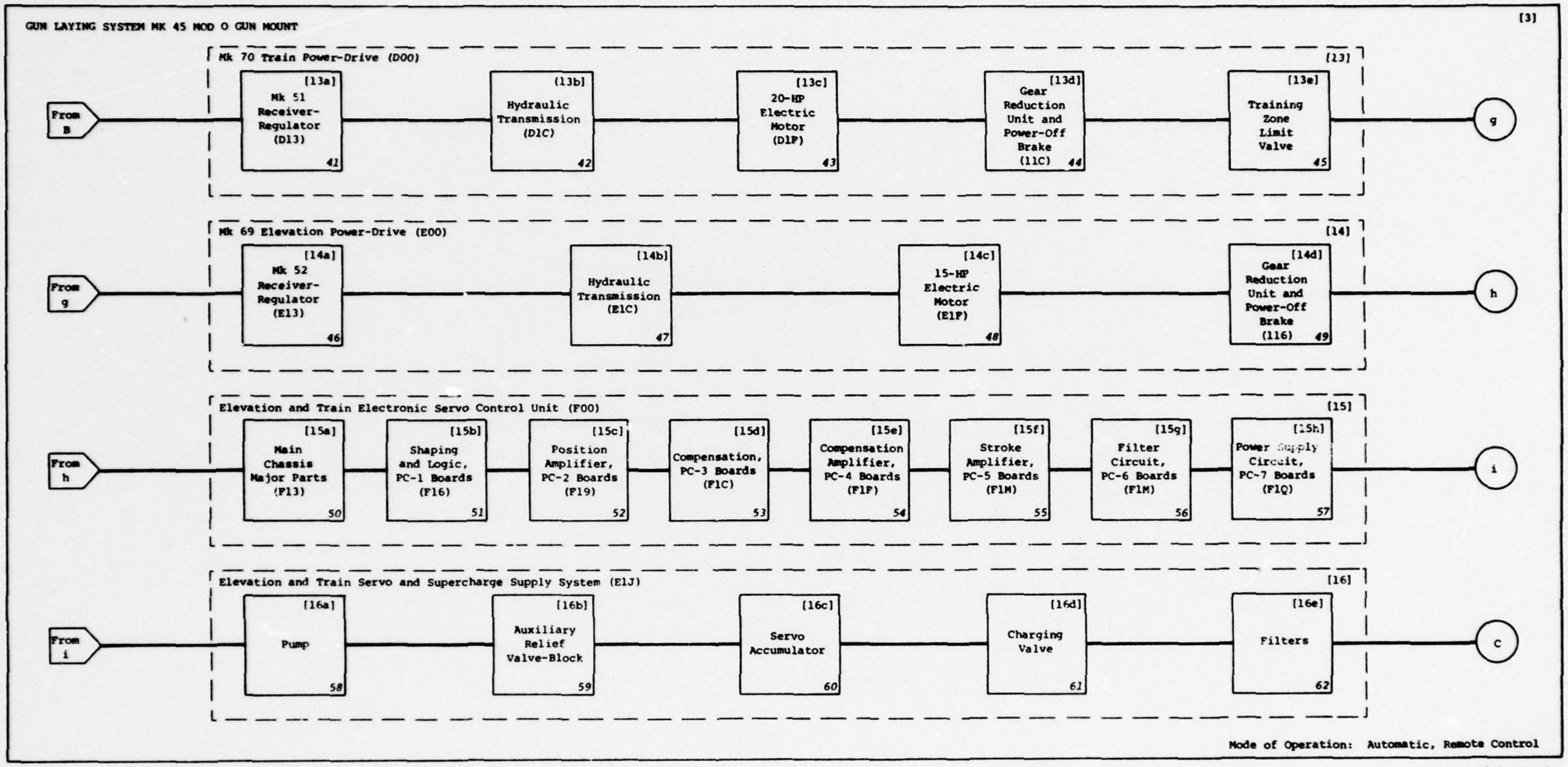
GUN LOADING SYSTEM RELIABILITY BLOCK DIAGRAM



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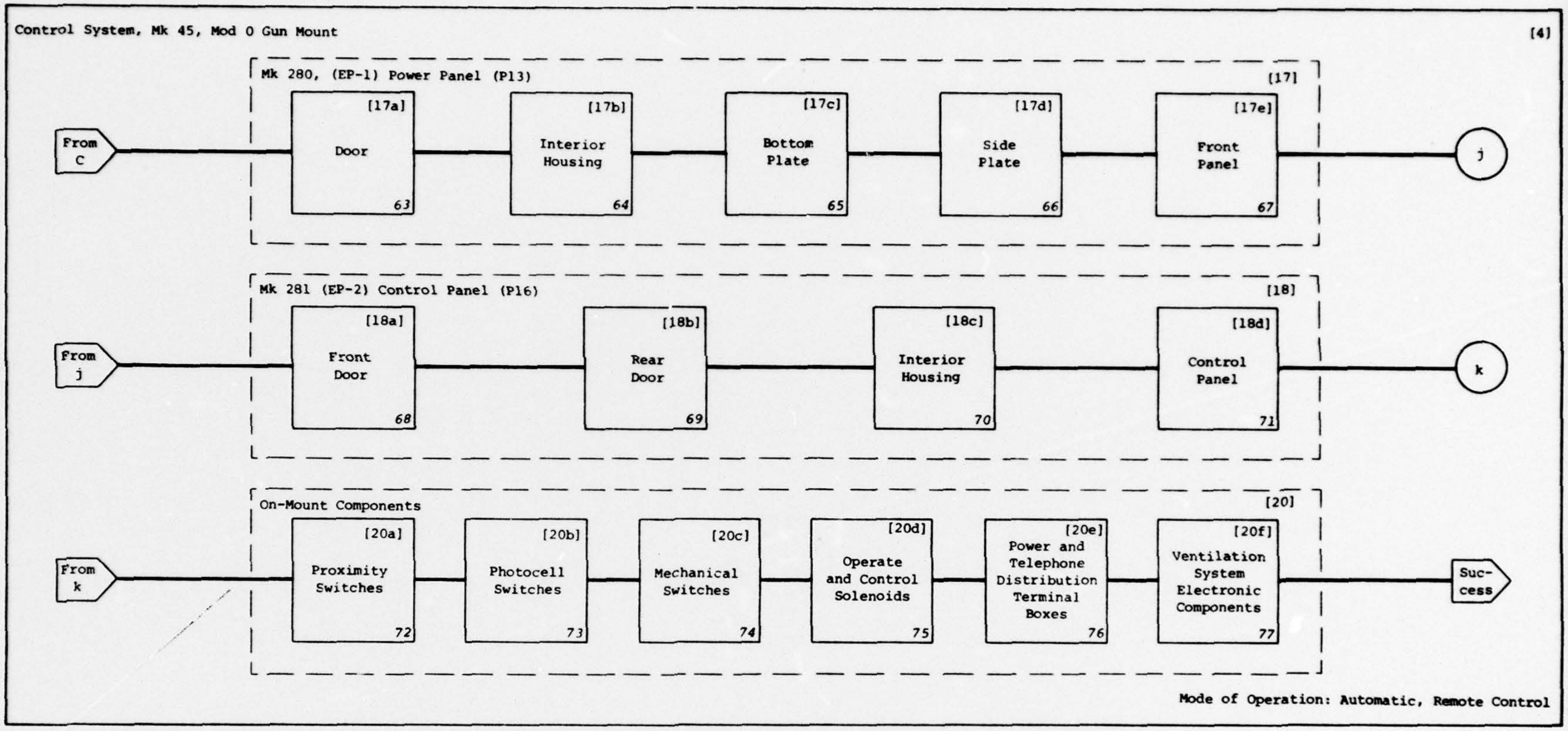
GUN LAYING SYSTEM RELIABILITY BLOCK DIAGRAM



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CONTROL SYSTEM MK 45 MOD 0 GUN MOUNT